Earthquakes in the New Madrid Seismic Zone—What should we expect?

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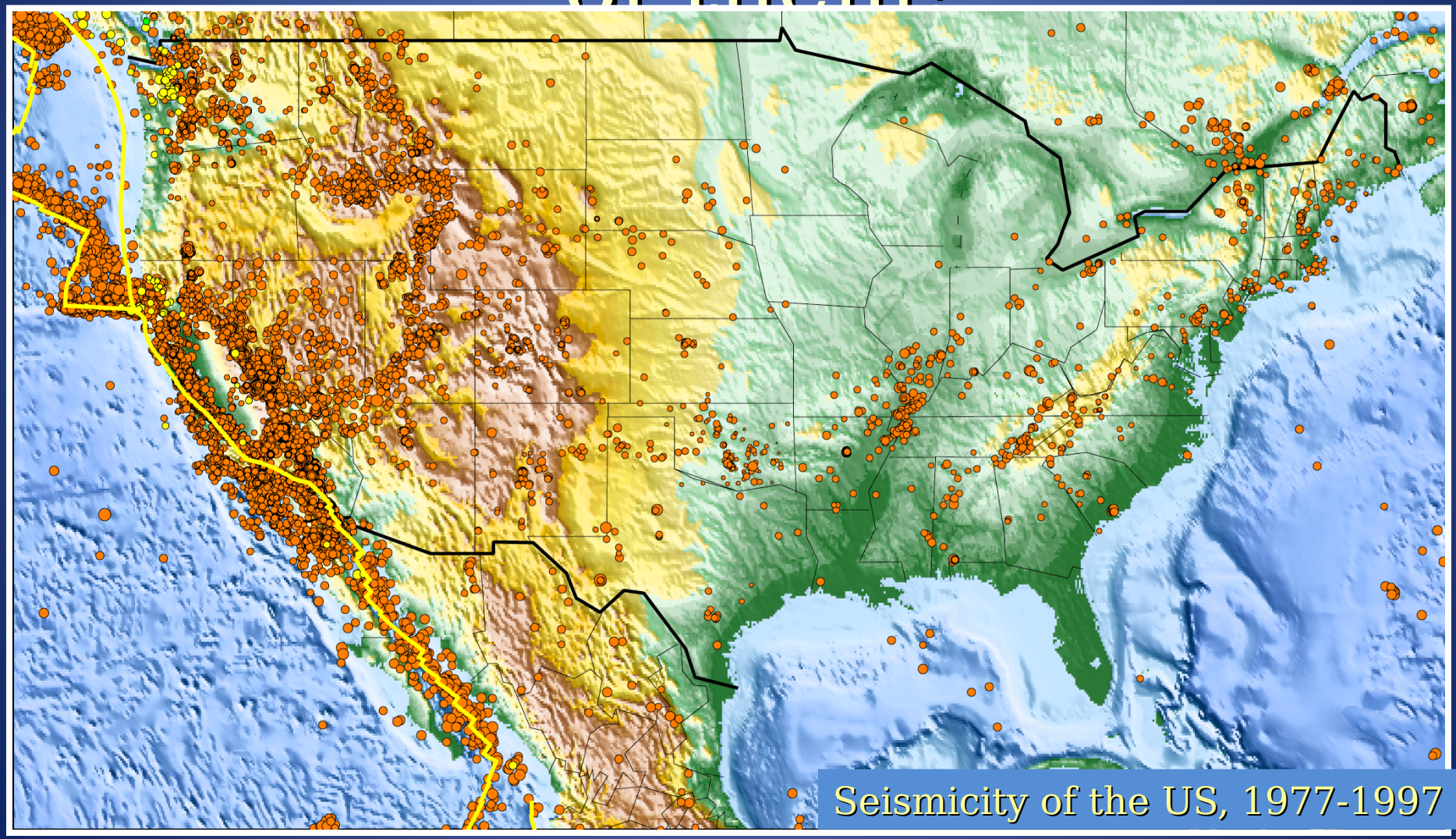
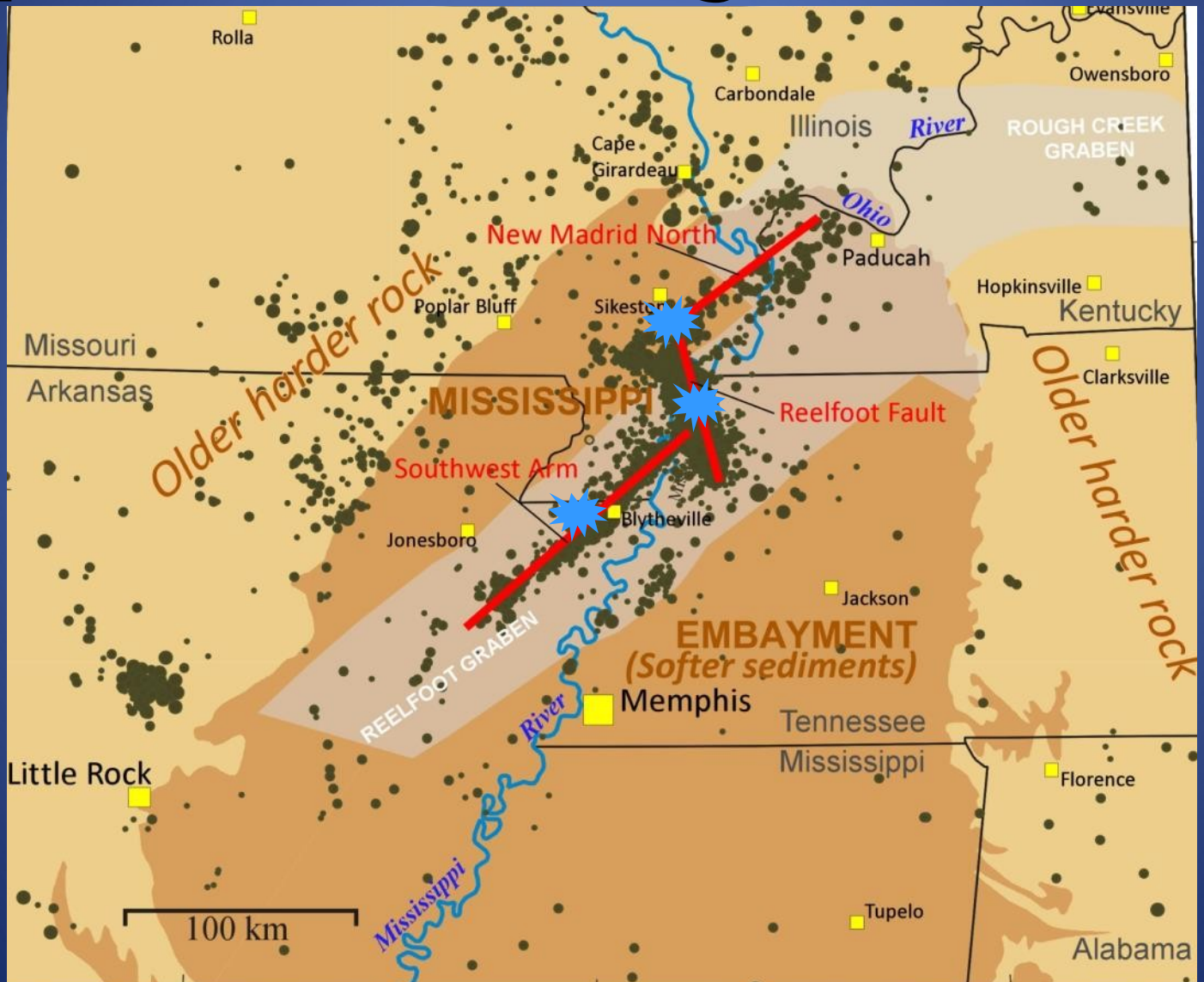
Most earthquakes occur along plate boundaries, but not all of them!



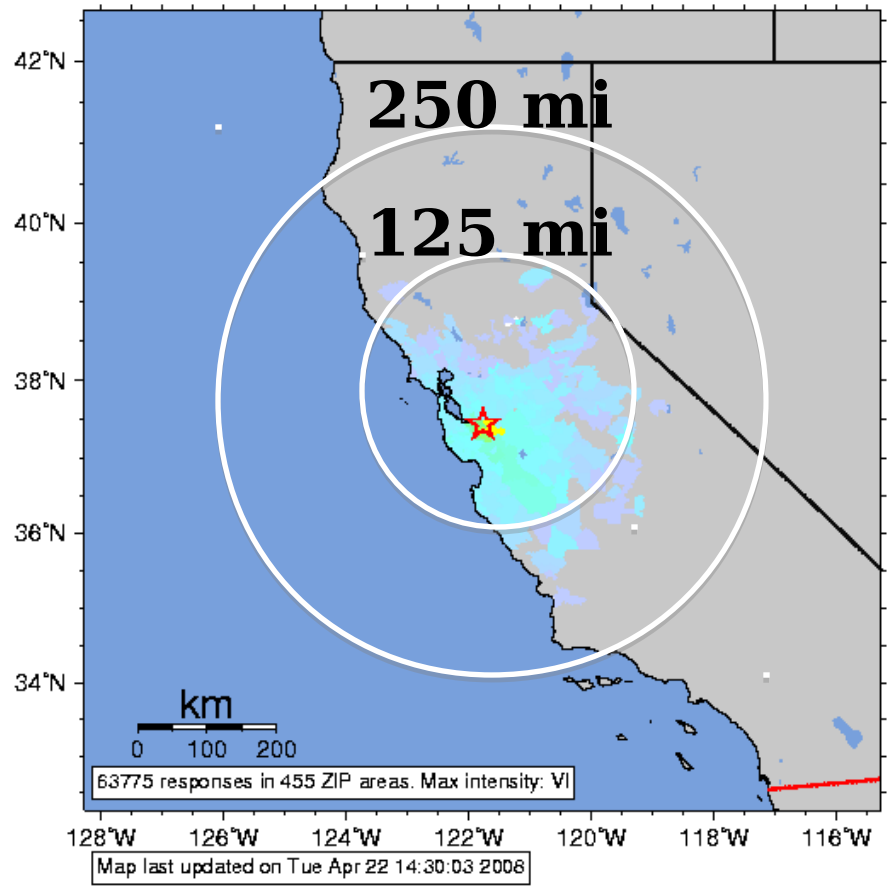
Seismicity of the US, 1977-1997

New Madrid Seismic Zone: Important Geologic Structures



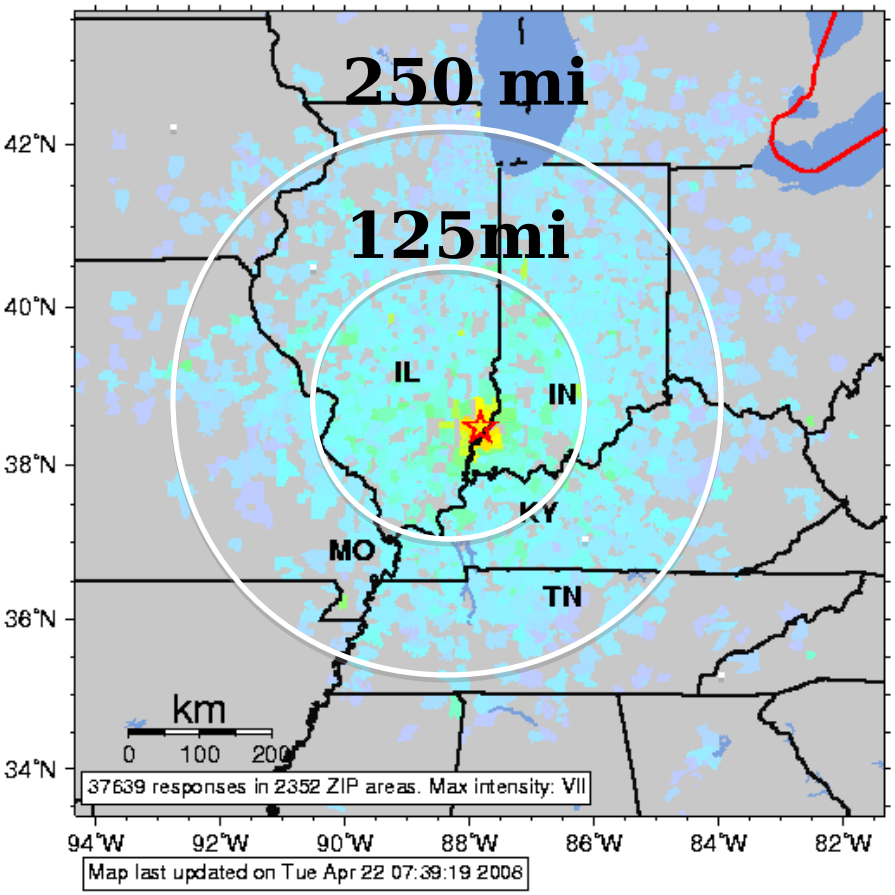
widely felt

M-5.4 Alum Rock, CA, 30 Oct 2007



INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

M-5.2 Illinois, 18 Apr 2008



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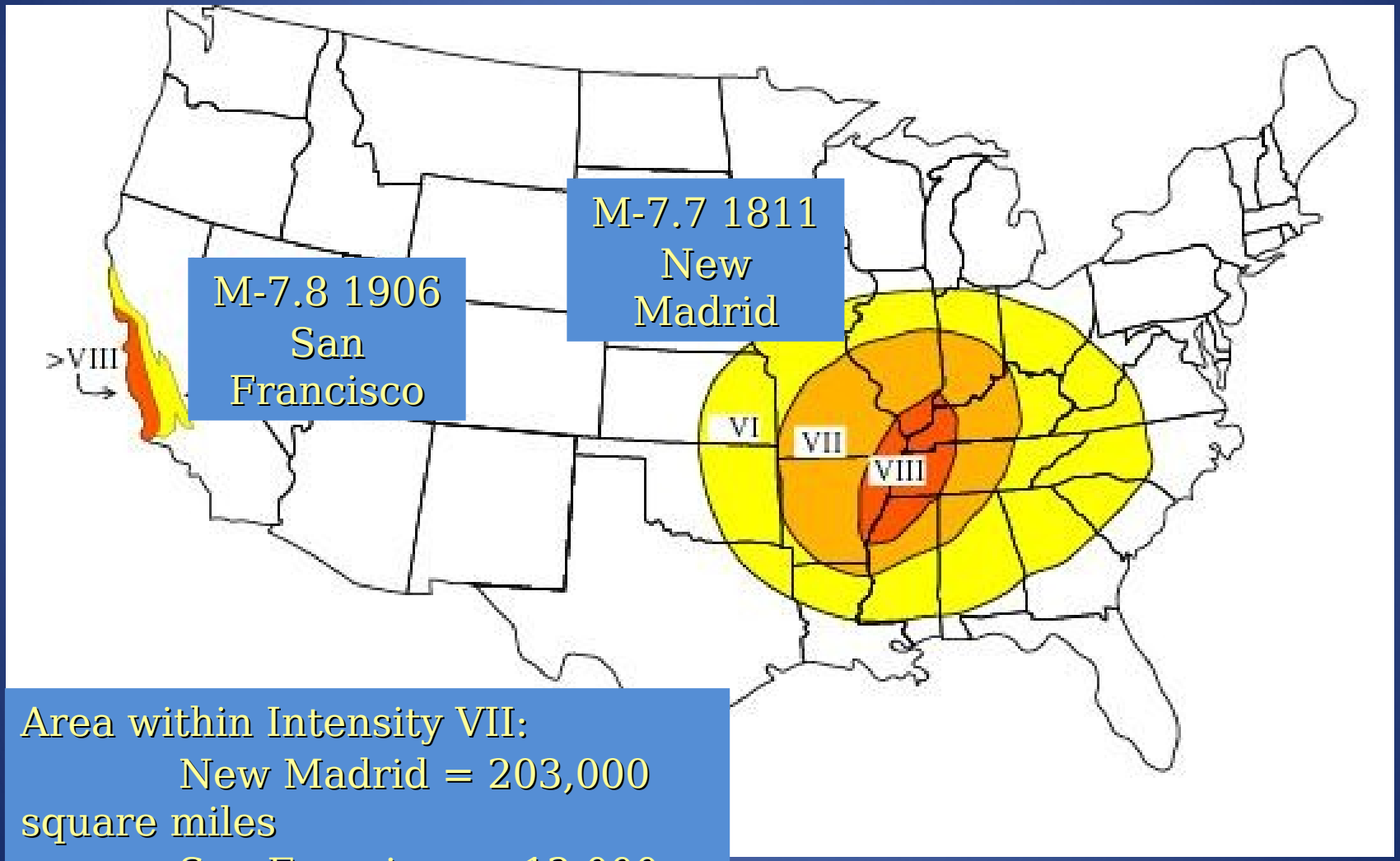
1811 versus 1906



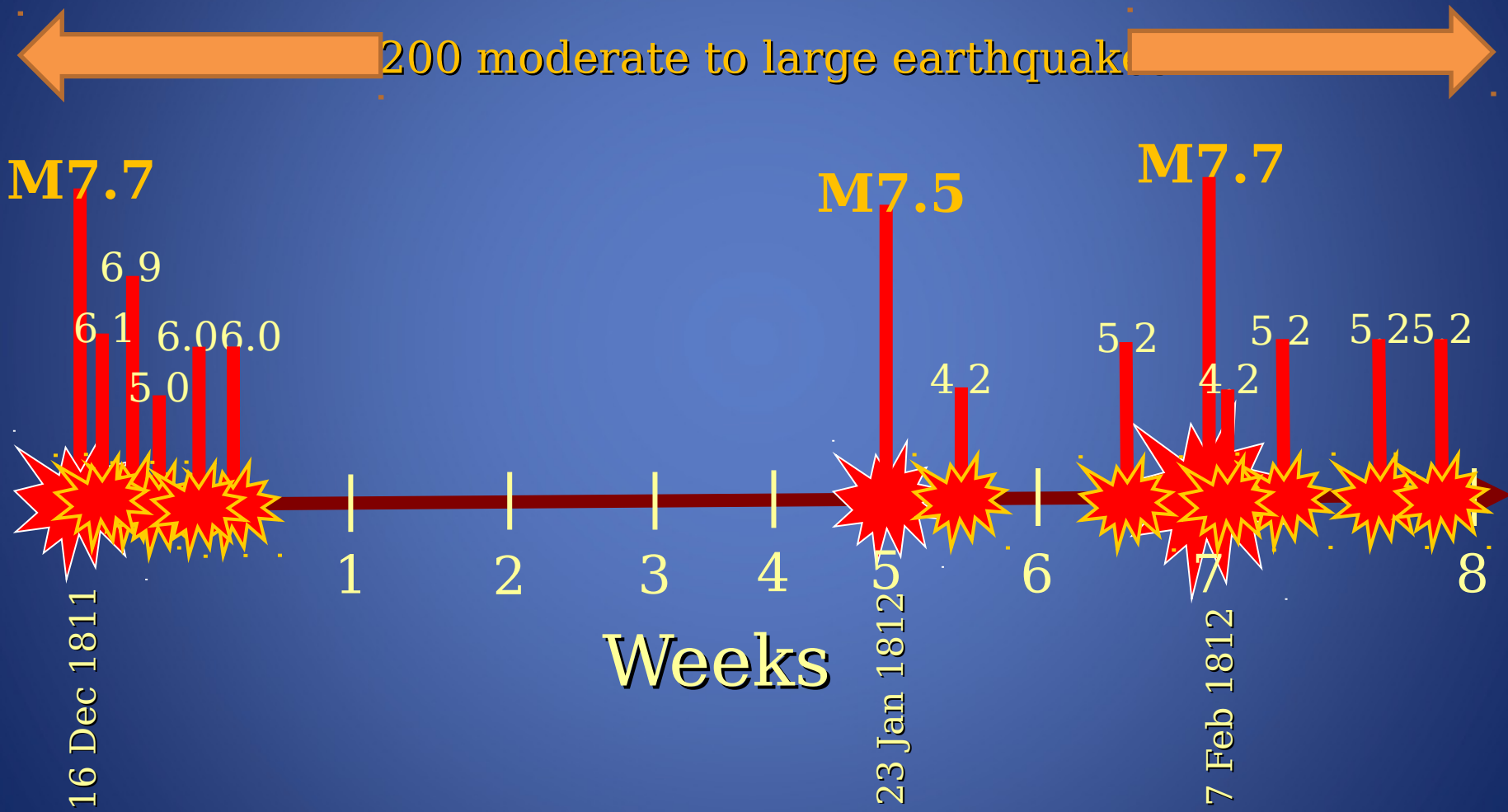
Area within Intensity VII:

New Madrid = 203,000 square miles

San Francisco = 12,000 square miles

The 1811-1812 New Madrid Earthquakes

Mainshocks and significant aftershocks



What happened in 1811-1812?

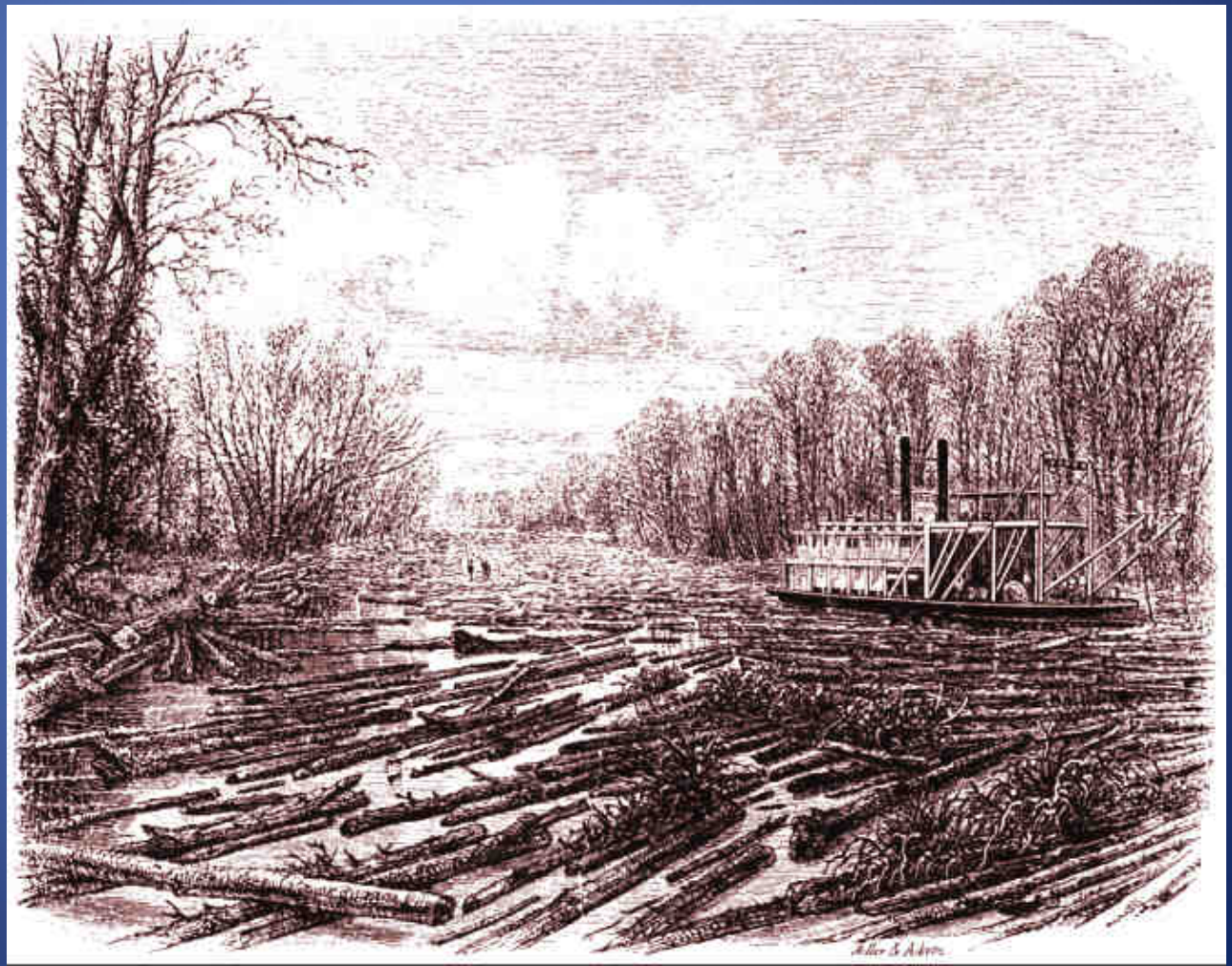
- Felt over 2 million square miles
  - ✓ Canada, East Coast, Florida
- Damage occurred over 230,000 square miles
- Geologic deformation—river-bank collapses, subsidence, uplift, liquefaction, and landslides—occurred over about 50,000 square miles
  - ✓ Cairo to Memphis, Crowleys Ridge to the Chickasaw bluffs

Geologic deformation

River-bank collapse

Geologic deformation

River-bank collapse

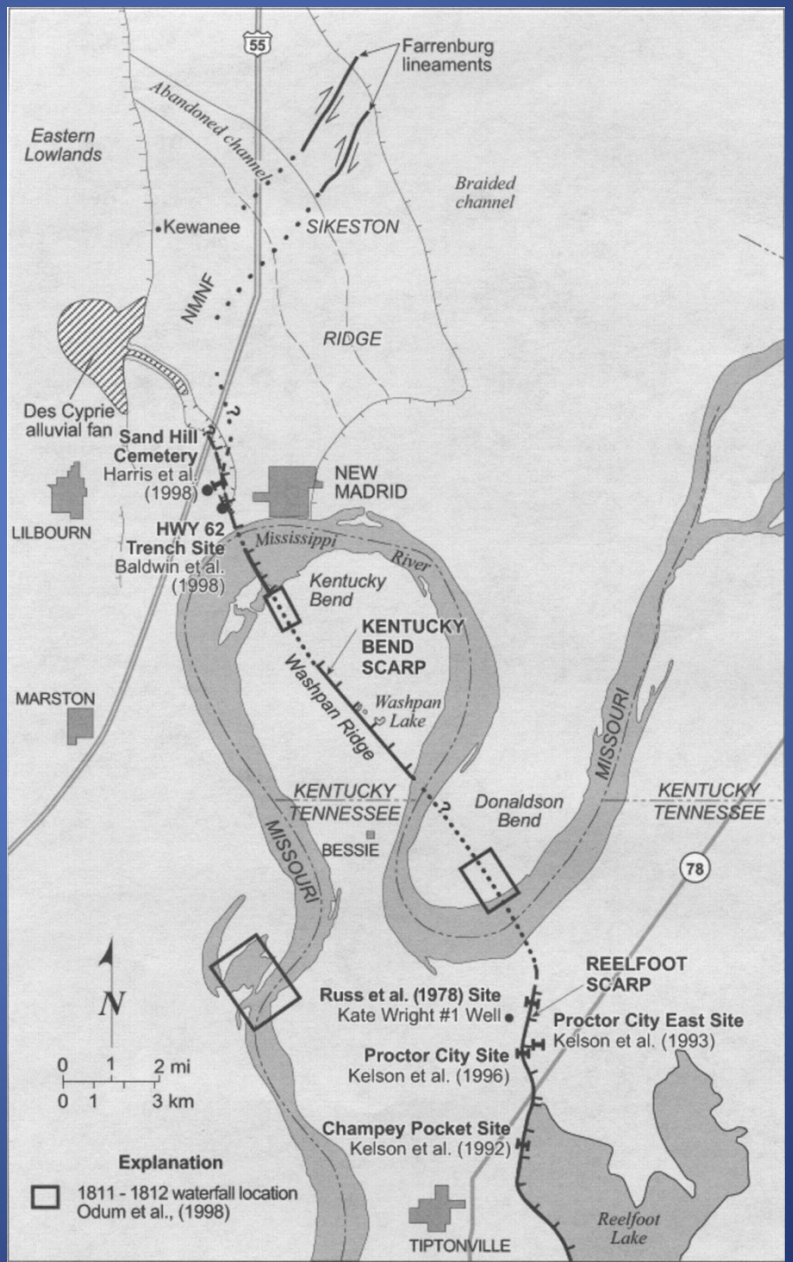


Geologic deformation

Subsidence

Geologic deformation

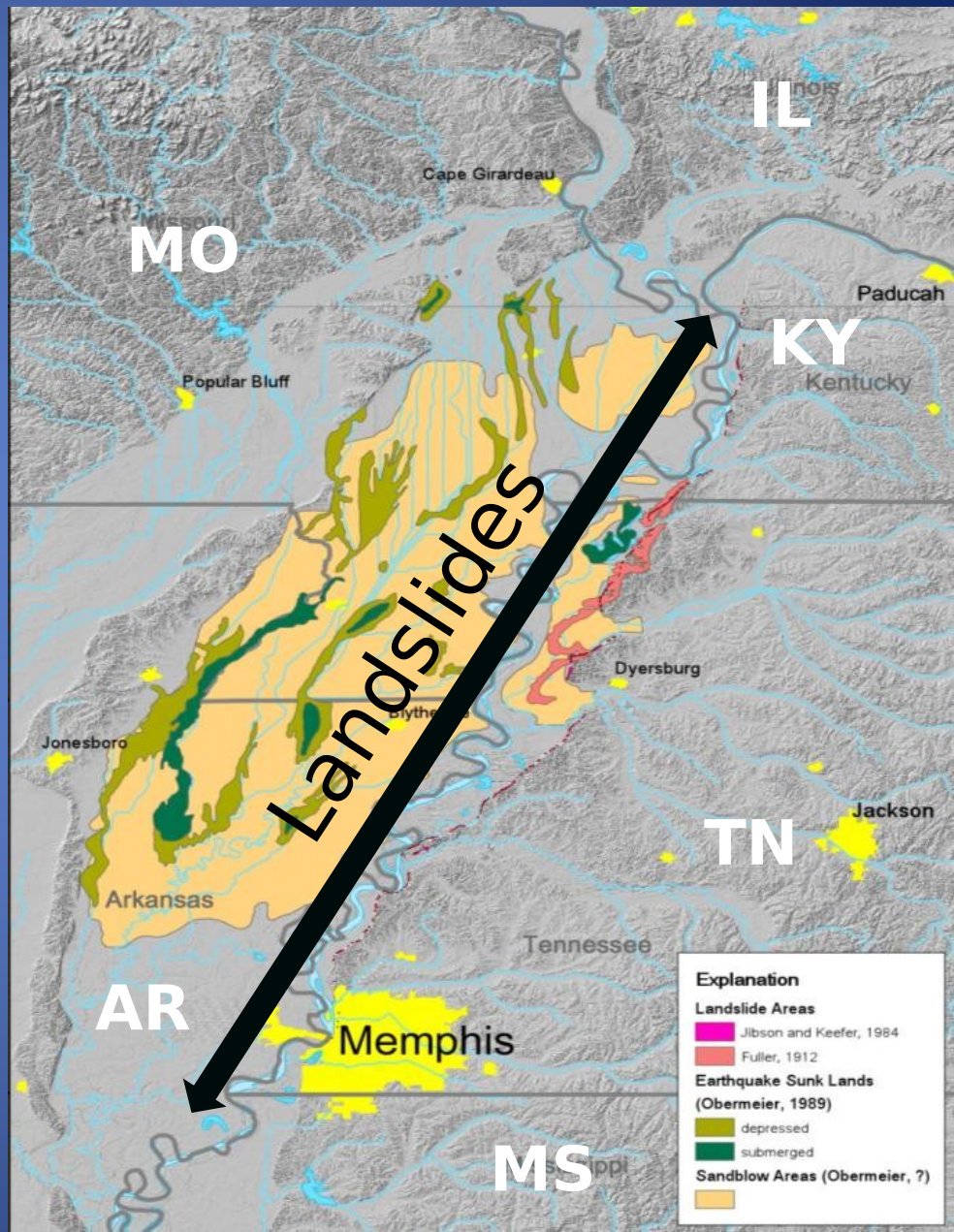
Uplift



Geologic deformation

Landsliding

- More than 220 large landslides mapped along about 200 miles of bluffs from Kentucky to Mississippi
- Other landslides were likely triggered up to 250 miles from the epicenters

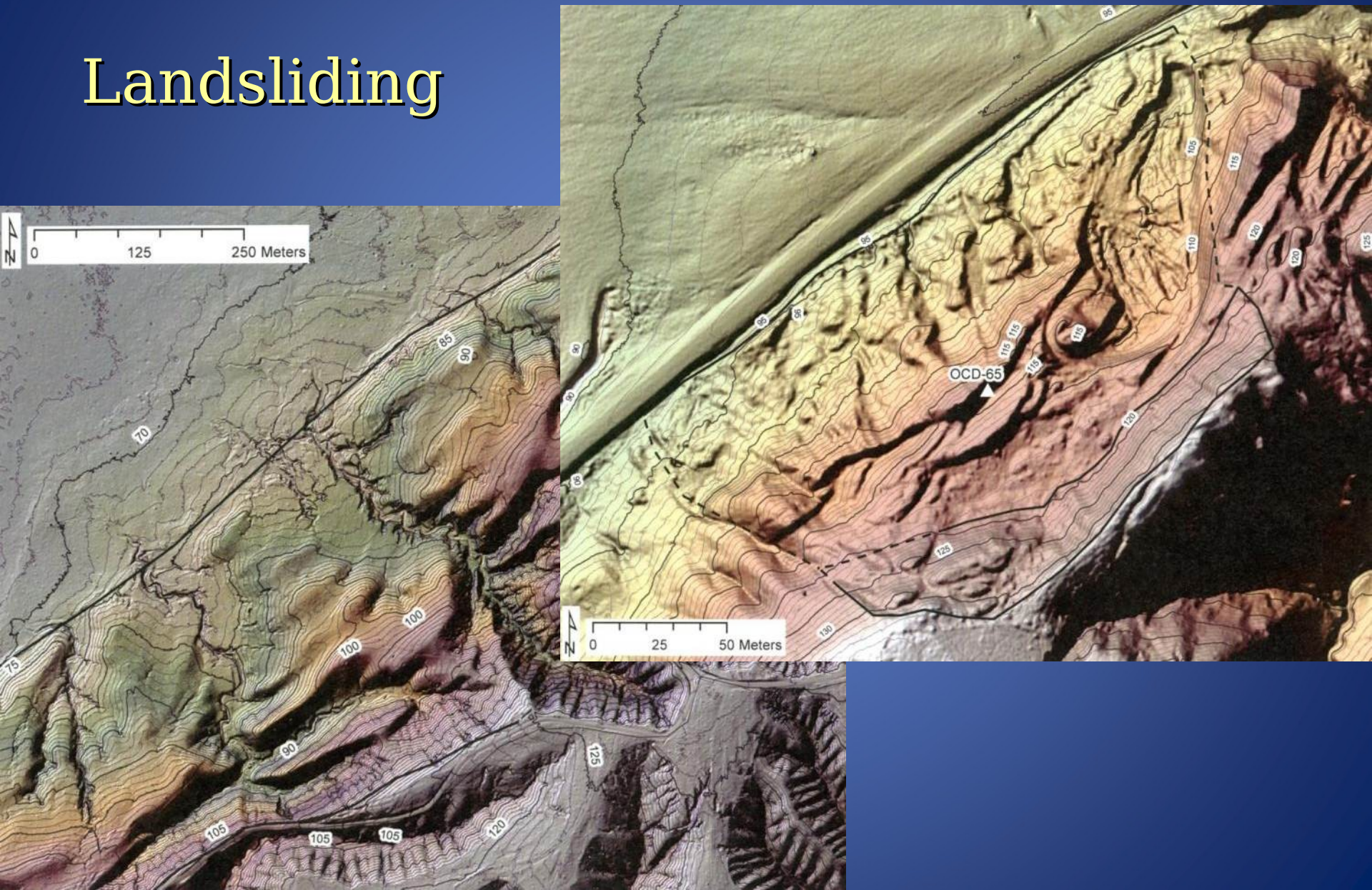


Geologic deformation

Landsliding

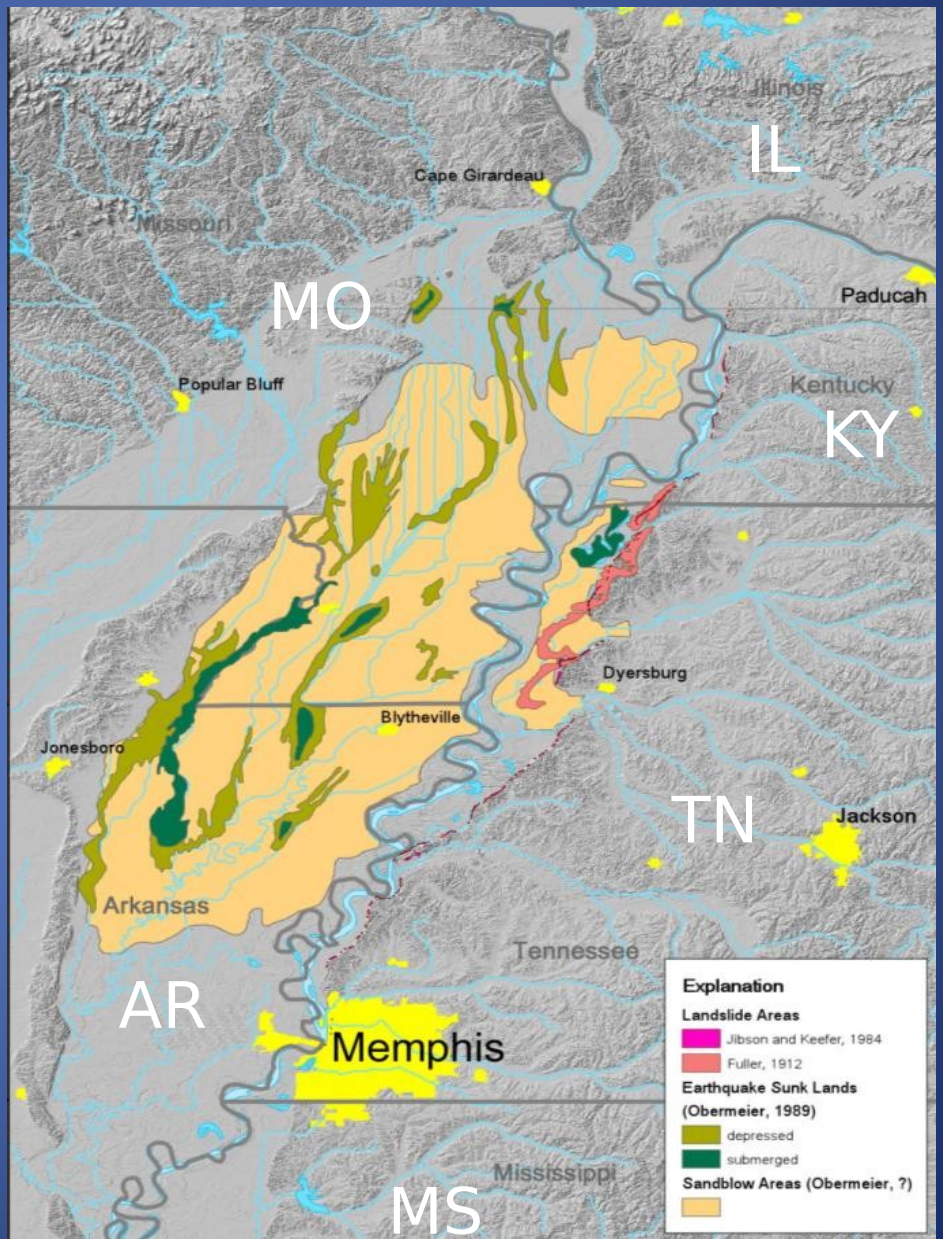
Geologic deformation

Landsliding



Geologic deformation

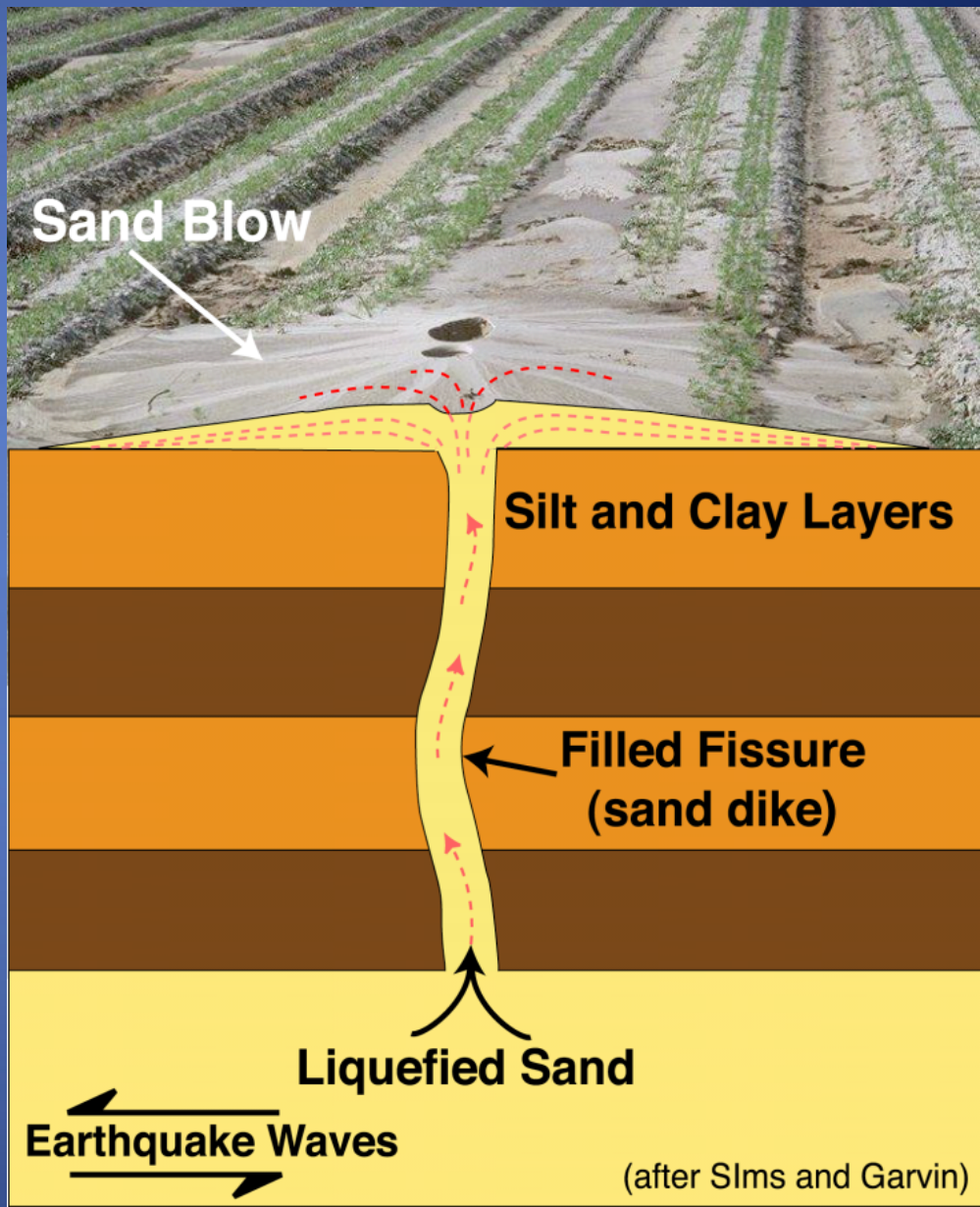
Liquefaction



Geologic deformation

iquefaction and and blow formation:

- During earthquake, water-saturated sand is shaken.
- If shaking is strong and lasts long enough, pore-water pressure builds up; the sand loses its strength and acts like a liquid.
- A pressurized slurry of water and sand erupts



Geologic deformation

iquefaction and
ateral spreading

Geologic deformation

Liquefaction

Some facts about the New Madrid Seismic Zone:

- New Madrid Seismic Zone produced large quakes in 1811-12, ~1450 AD, ~900 AD, and ~2350 BC
- During past 1200 years, the average time between these events is about 500 years
- The prehistoric earthquakes were similar in size to the 1811-1812 earthquakes
- Each New Madrid event was a sequence of earthquakes, including multiple very large mainshocks, much like the 1811-1812 sequence

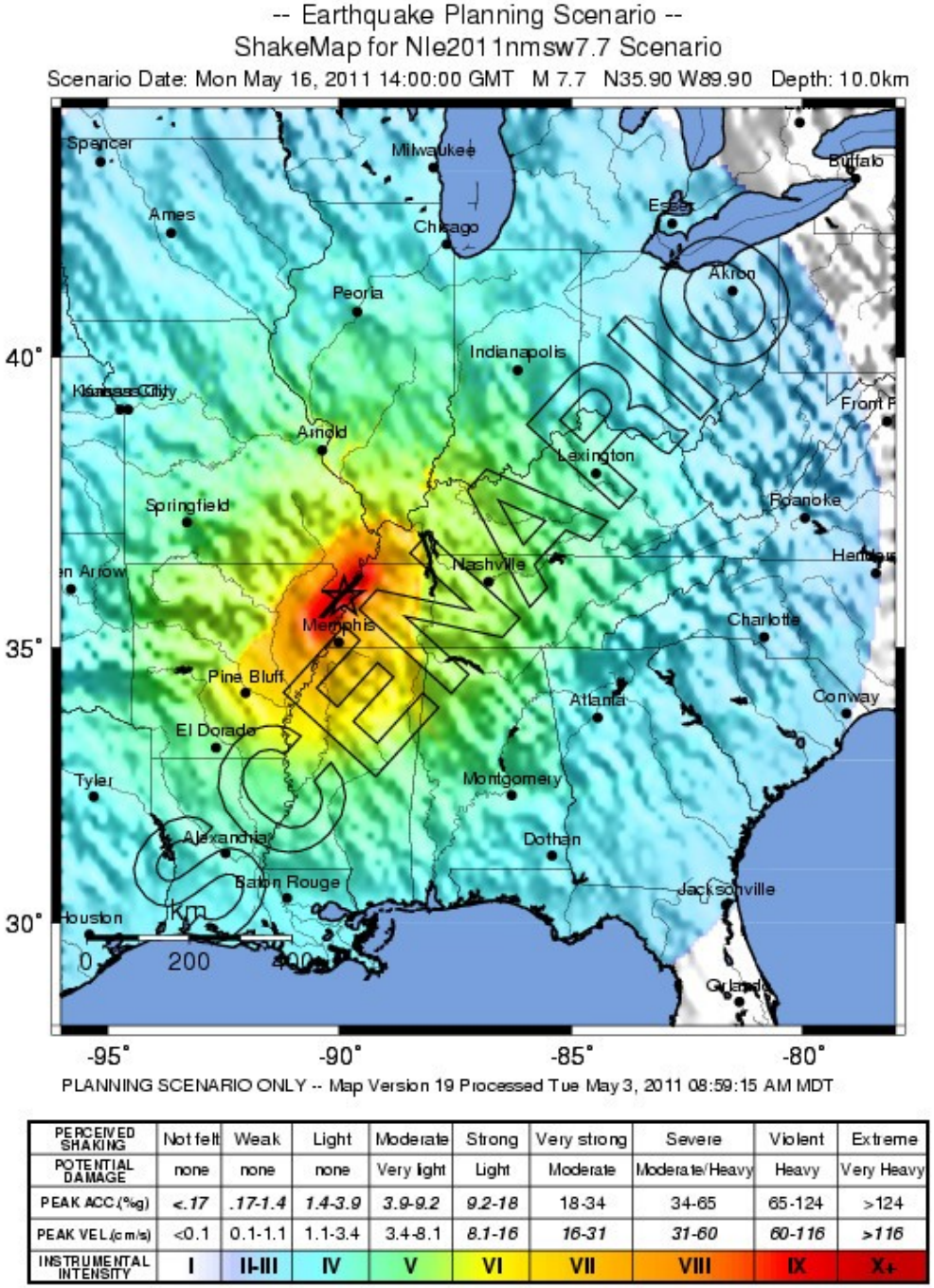
50-year earthquake probabilities in the New Madrid Seismic Zone

- Repeat of 1811-1812 (M 7.5-8.0)
  - 7-10%
- Magnitude 6.0 or greater
  - 28-46%
- Magnitude 5.0 or greater
  - High probability

What will happen in a future major earthquake?

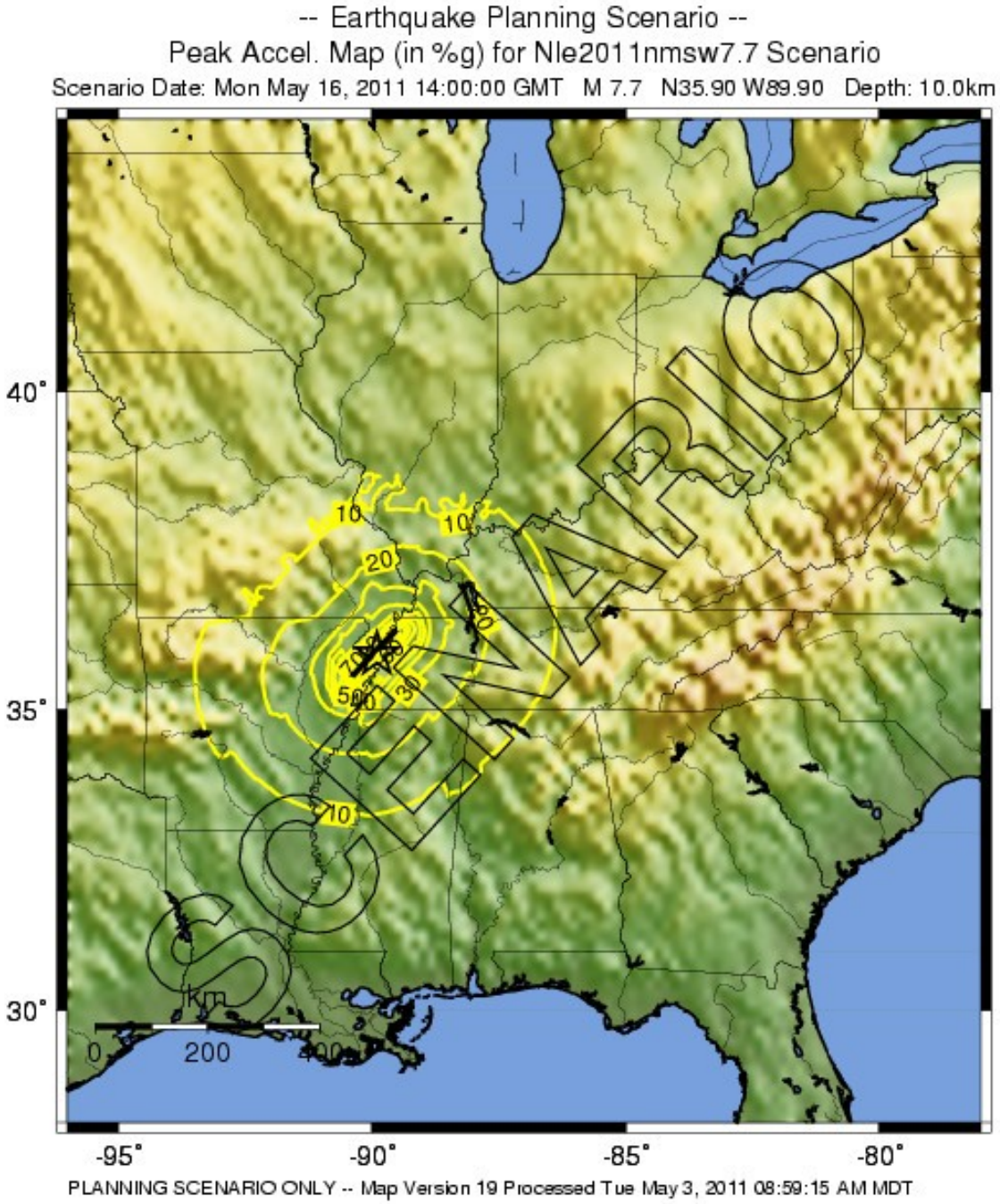
"The past is the key to the future"

Strong shaking

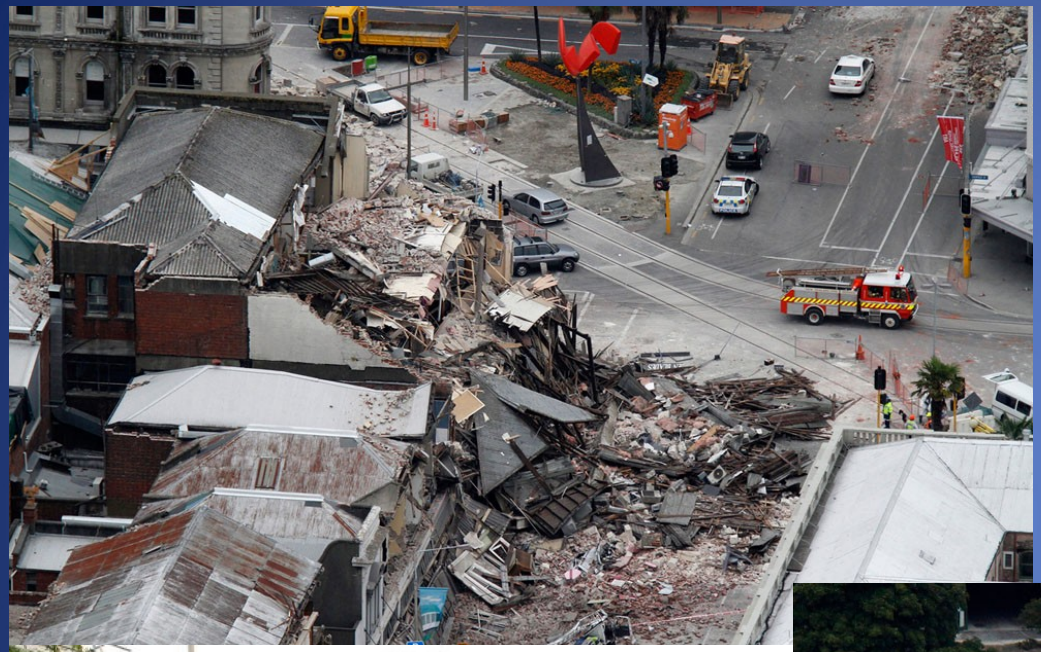


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Strong shaking



Building damage

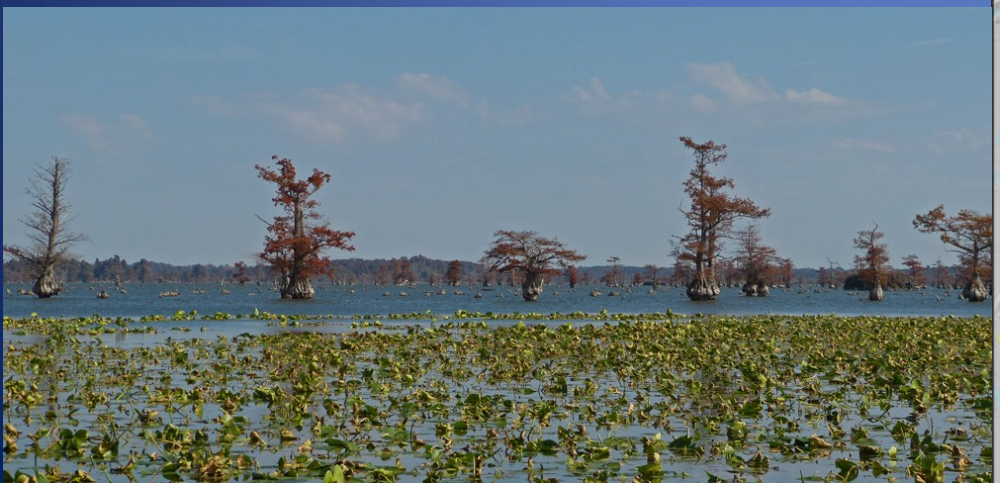


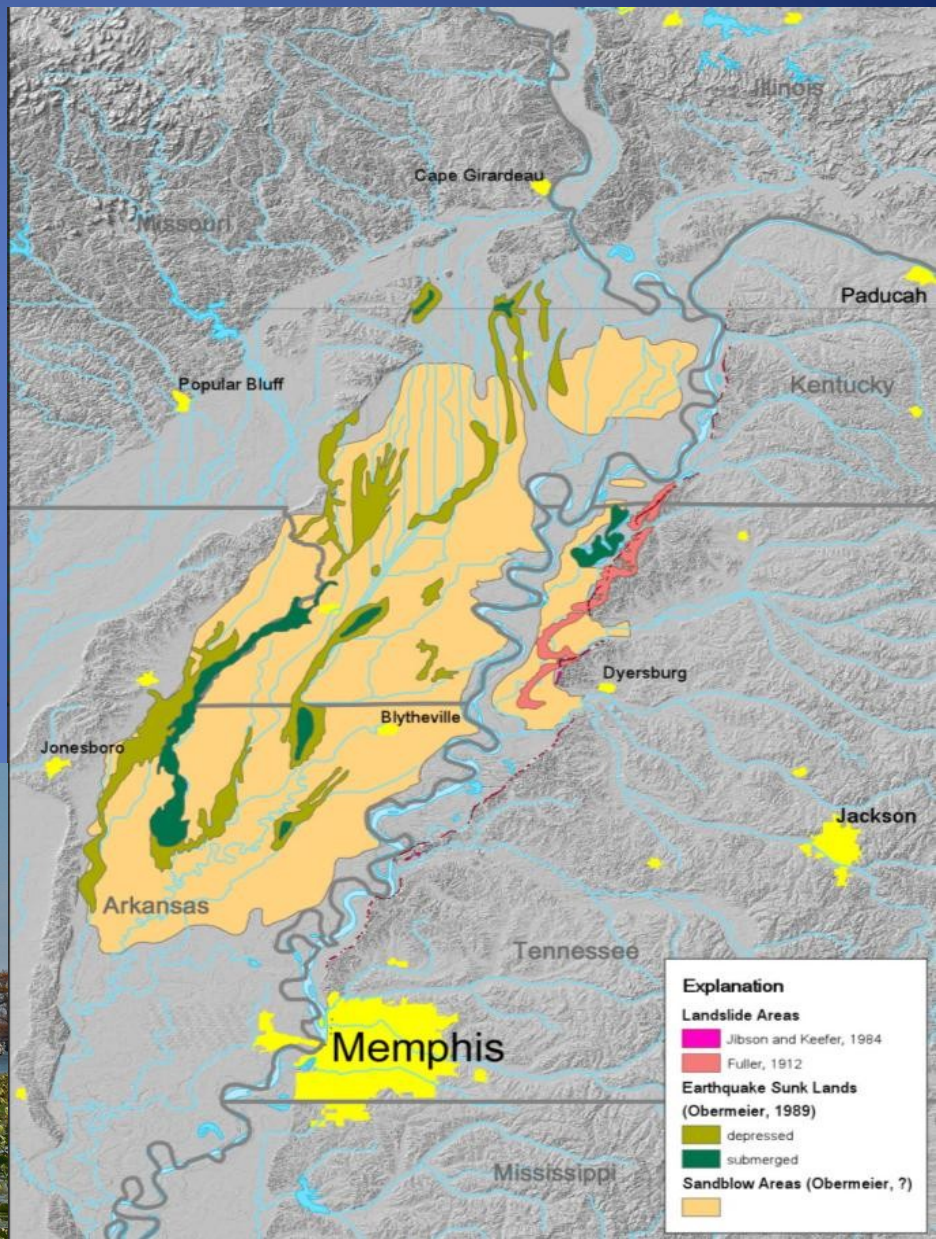
River-bank collapse

- Extensive bank failures for perhaps 100 miles in either direction from the epicenter
- Huge amounts of timber and debris in the river

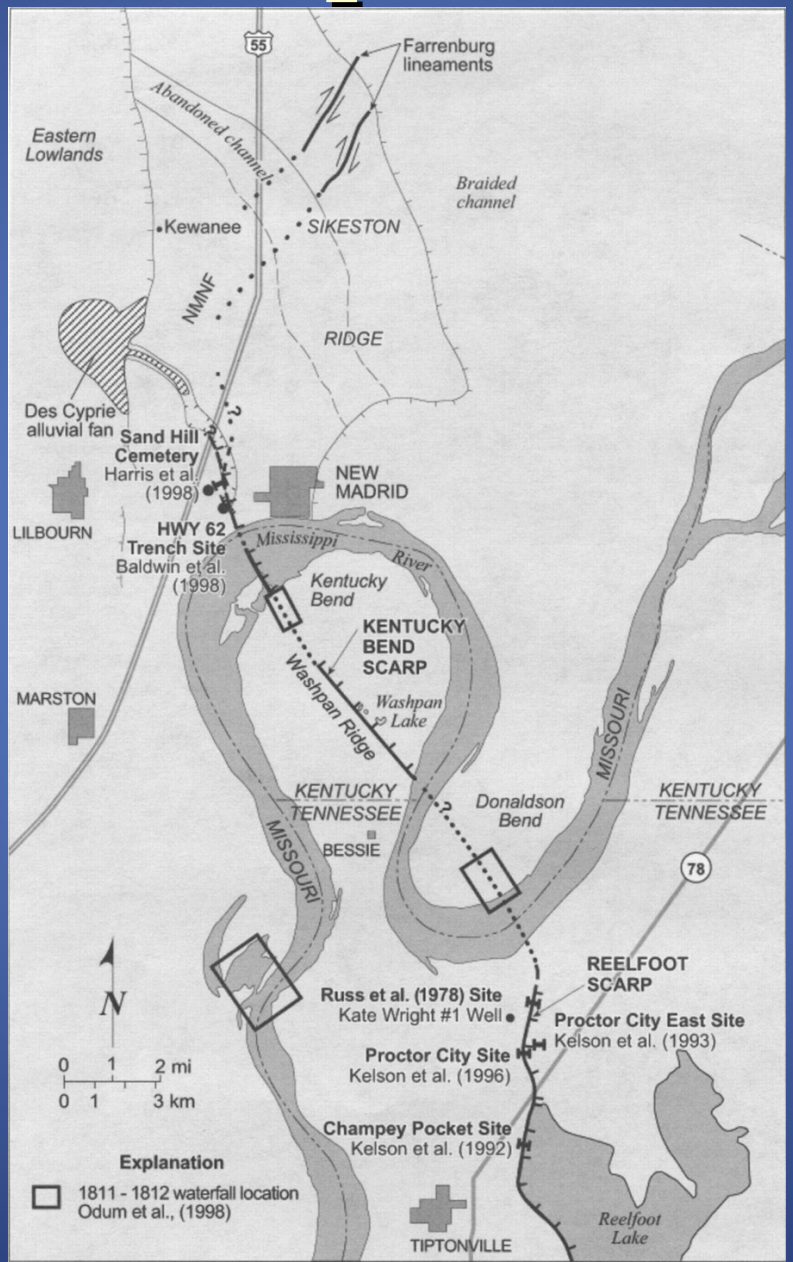
Subsidence

- Thousands of square miles subside as much as 15 feet
- Flooding of subsided areas



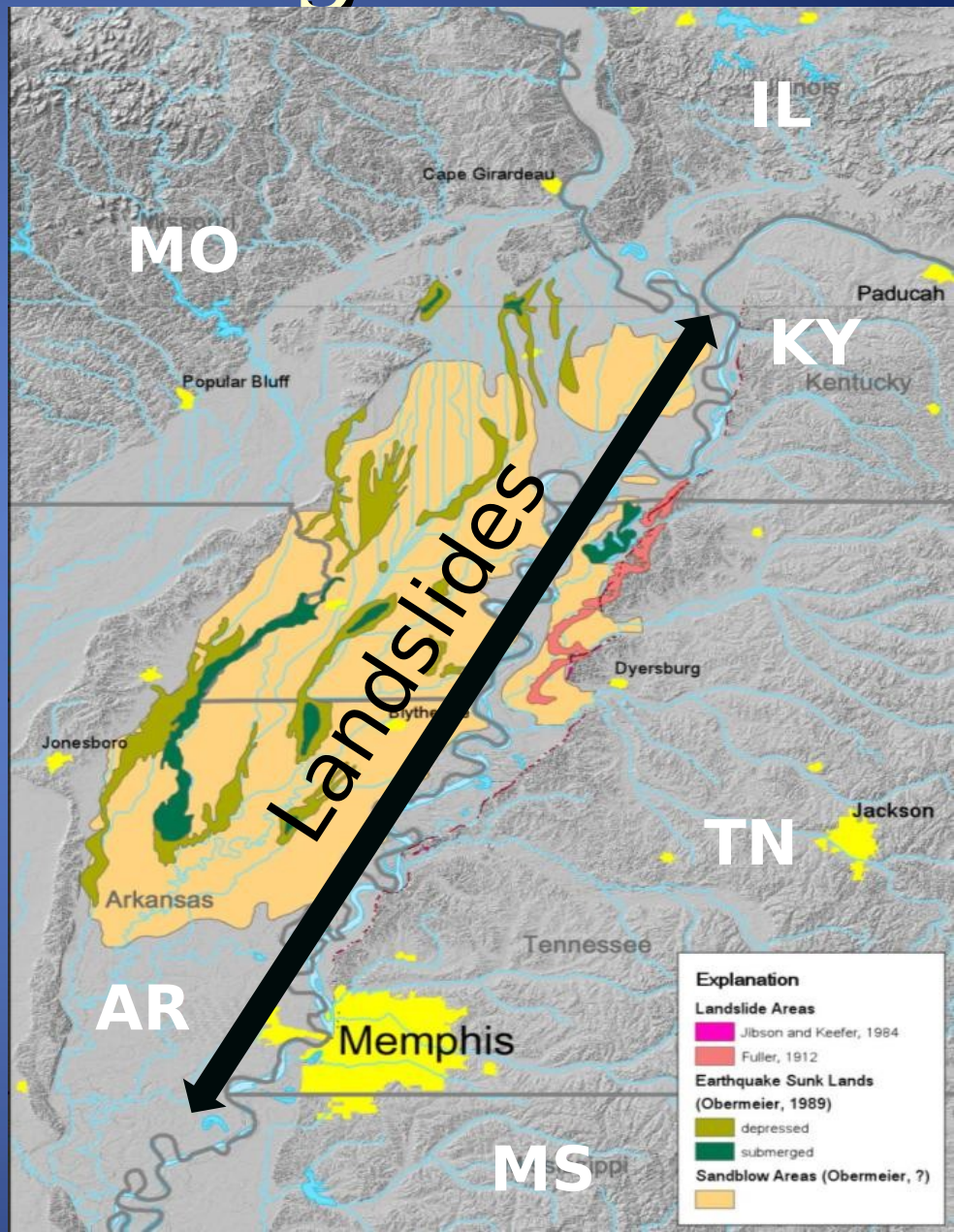


Uplift


55
Farrenburg lineaments
Abandoned channel
Eastern Lowlands
Braided channel
Kewanee
SIKESTON
NMNF
RIDGE
Des Cyprie alluvial fan
Sand Hill Cemetery
Harris et al. (1998)
NEW MADRID
LILBOURN
HWY 62 Trench Site
Baldwin et al. (1998)
Mississippi River
Kentucky Bend
KENTUCKY BEND SCARP
Washpan Ridge
Washpan Lake
MARSTON
KENTUCKY
TENNESSEE
MISSOURI
BESSIE
Donaldson Bend
78
REELFOOT SCARP
Russ et al. (1978) Site
Kate Wright #1 Well
Proctor City East Site
Kelson et al. (1993)
Proctor City Site
Kelson et al. (1996)
Champey Pocket Site
Kelson et al. (1992)
N
0 1 2 mi
0 1 3 km
Explanation
1811 - 1812 waterfall location
Odum et al., (1998)
TIPTONVILLE
Reelfoot Lake

Landsliding

- Large landslides on bluffs from Cairo to Memphis and on Crowleys Ridge



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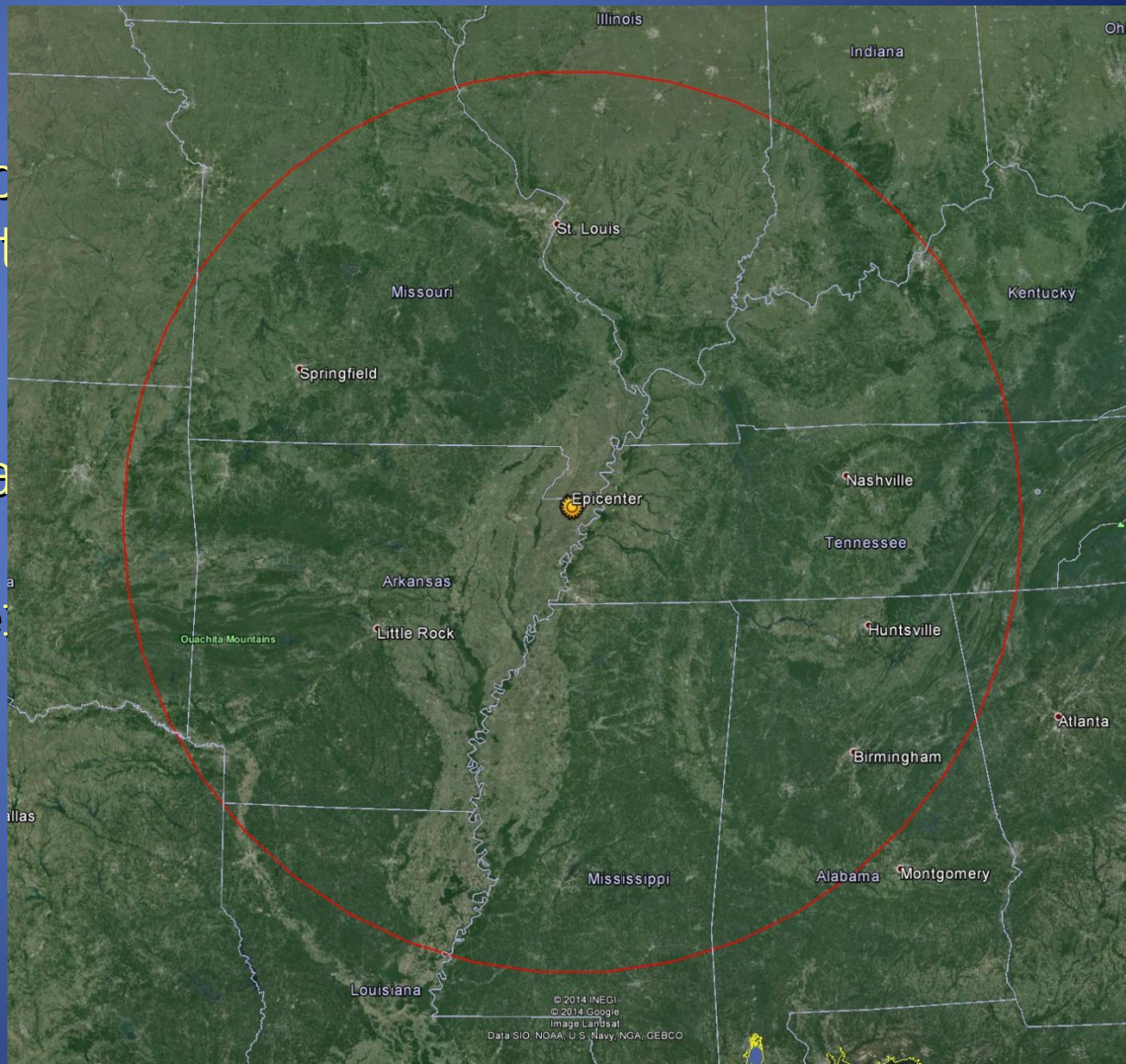
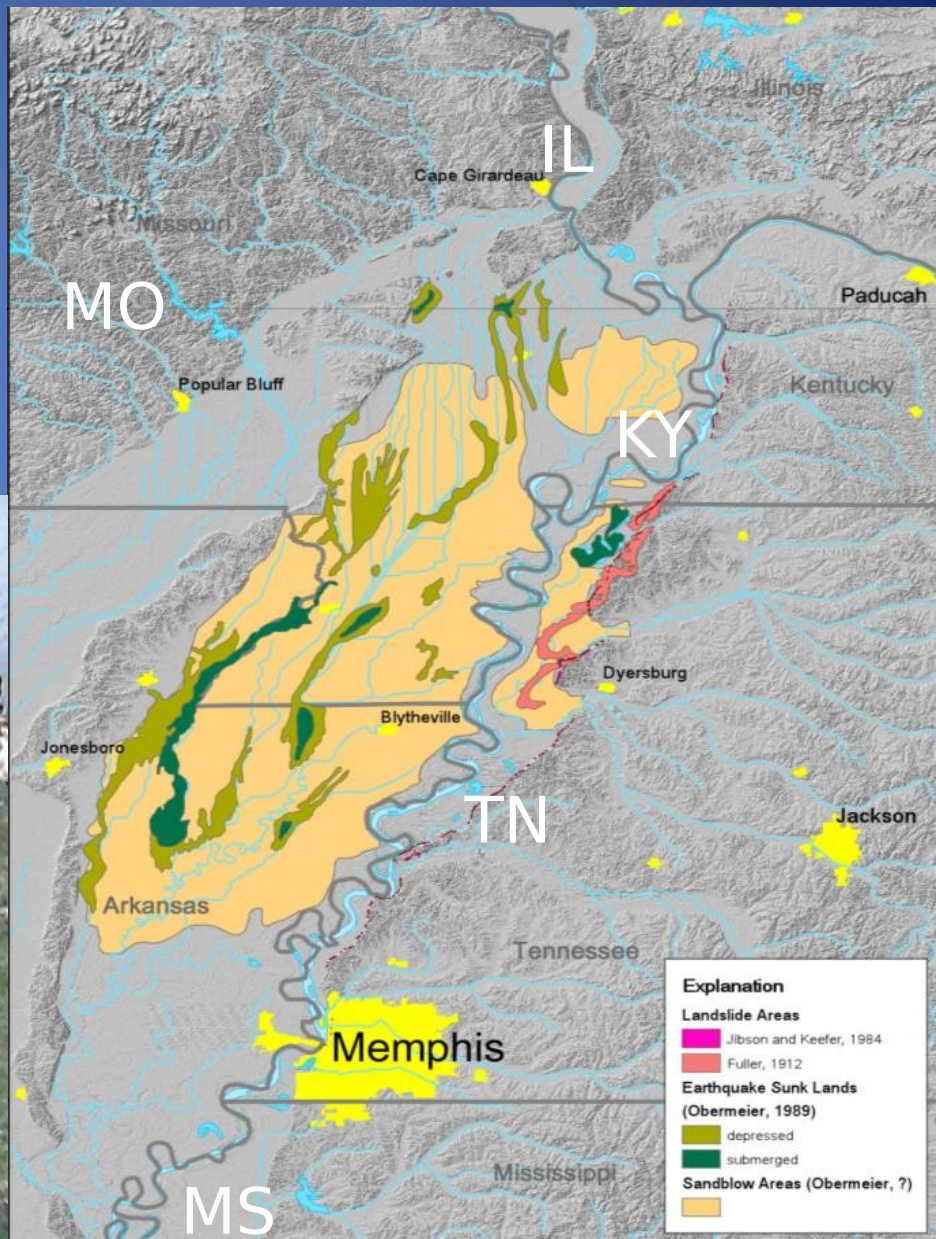


Liquefaction

- More than 50,000 square miles could be affected
- As much as 6 feet of sand could be deposited on the



Effects

Agriculture

Effects

Roads

Effects

Roads

Effects

Bridges

Effects

Railroads

Effects

Rivers

Effects

Rivers

Effects

Levees

Effects

Ports

Effects

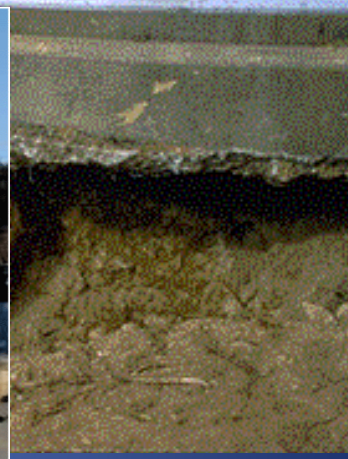
Power lines

Effects

Undergro
und
utilities

Effects

Fuel



Summary of the hazard

- The NMSZ experienced multiple magnitude-7+ earthquakes in 1811-1812 and at least three prior times in the last 5,000 years.
- The NMSZ is currently producing earthquakes; it is the most active zone in eastern North America.
- Large earthquake sequences have occurred about every 500 years in the recent past.
- A magnitude-7+ earthquake is a low-probability, high-consequence event; a magnitude-6+ earthquake has higher probability and also can cause significant damage.
- The consequences of a future major earthquake sequence in the NMSZ will be very serious if not catastrophic.

Sources of additional information

- Real-time and background information on earthquakes *earthquake.usgs.gov*
- New Madrid bicentennial web site:

  newmadrid2011.org
- National Earthquake Hazards Reduction Program:

  www.nehrp.gov

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